The Sudbury Neutrino Observatory: Experiment to Determine the Relative Intensity of the 6.1 and 7.1 MeV γ-rays Resulting from ^{16}N β-decay

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Energy calibration defines a relationship between neutrino energy and number of PMTs that detect light. The γ-ray energy spectrum from ^{16}N decay has lines at 6.1 and 7.1 MeV that account for 99% of all γ-rays emitted. The published uncertainty in the intensity of the 7.1 MeV line is 8.3% [1]. Because the SNO detector will not resolve the 6.1 and 7.1 MeV lines, this leads to a systematic uncertainty in the mean γ-ray energy of 0.7%, which is much greater than the expected 0.1% statistical uncertainty.

An experiment to directly measure the relative intensity of the 6.1 and 7.1 MeV γ-rays from ^{16}N β-decay was performed at the LBNL 88" cyclotron. The reaction ^{16}O(n,p)^{16}N was made on water with 14+ MeV neutrons in Cave 0. The water was pumped via a hose through Cave 1 to the atrium. A high purity germanium γ-ray detector measured the γ-ray energy spectrum. Acrylic water cells were fabricated and used at the beam stop and the Ge detector to increase the target and counting volumes, respectively.

It was crucial to establish the Ge detector efficiency for 7.1 MeV γ-rays relative to the efficiency for 6.1 MeV γ-rays. Our procedure involved Monte Carlo simulation using GEANT and data from a solution containing ^{56}Co. The Ge detector efficiency for 6.1 and 7.1 MeV γ-rays as well as for the ^{56}Co γ-rays was simulated. The efficiency for 7.1 MeV relative to 6.1 MeV was found. Then the relative efficiency for ^{56}Co γ-ray energies relative to the 2.589 MeV line were found. The ^{56}Co solution had been placed inside an acrylic cell and counted in the same geometry as the ^{16}N solution. This data was analyzed to determine the relative efficiency of the Ge detector.

The ^{16}N data is being evaluated. A partial energy spectrum is shown in Figure 1. Preliminary work indicates the 7.1 MeV intensity to be 7.70±2.0±0.868%, where the first uncertainty is systematic, and the second is statistical. The uncertainty in the mean γ-ray energy is now approximately 0.2%. The results from this experiment at LBNL will decrease the SNO energy calibration uncertainty, which will enable determination of the ^{8}B solar neutrino energy spectrum with greater precision.

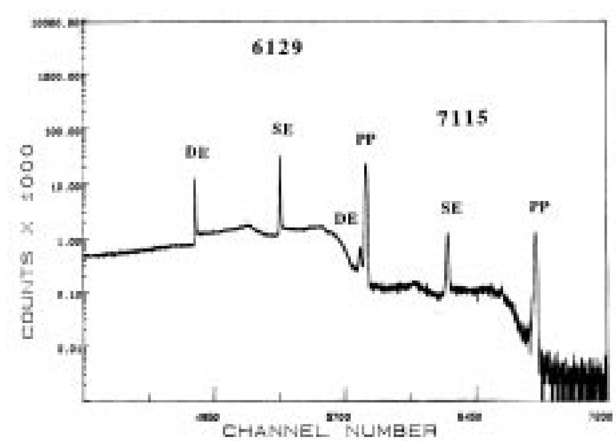

Figure 1: ^{16}N partial energy spectrum.

References

[1] Table of Isotopes, 8th Ed., R. Firestone.